Strengthening and underpinning the foundations of the main building of the Ministry of Foreign Affairs of Finland

Renforcement et reprise des efforts en sous-oeuvre des fondations de l`édifice principal du Ministère des Affaires Étrangères de Finlande

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XIV European Conference on Soil Mechanics and Geotechnical Engineering, 24th-27th September 2007, Madrid, Spain

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ABSTRACT

Strengthening and underpinning of the foundations of the main building of Ministry of Foreign Affairs of Finland was realised between the years 1985 and 1988. The building was built in the 1820´s for the Russian Navy and was designed by architect C. L. Engel (1778 – 1840). The building was founded on a massive stone foundations lying on moraine or rock. The purpose of the underpinning was to realize a new basement in the eastern part of the building and the old basement floor level had to be lowered in other parts. In the eastern part of the building the old foundation was from two to four meters above the new floor level.

RÉSUMÉ

Le renforcement et la reprise des efforts en sous-oeuvre the l`édifice principal du Ministère des Affaires Étrangères de Finlande ont été réalisés entre 1985 et 1988. L´édifice fut construit dans les années 1820 pour le compte de la marine de guerre et a été dessiné par l`architecte C. L. Engel (1778 – 1840). L`édifice fut érigé sur une fondation de blocs de pierre déposés sur un lit de moraine ou sur le roc. La repise des efforts en sous-oeuvre fut réalisée pour permettre l`aménagement d'un sous-sol dans l'aile est de l'édifice, ainsi que l'abaissement du plancher dans d'autres zones. Dans la partie est de l'édifice, l'ancienne fondation était de 2 à 4 mètres au dessus du niveau du nouveau plancher.

Keywords: strengthening, underpinning, blasting, shoring

1 HISTORY

Originally, from the 18th century, the area of the Naval Barracks, known today as "Merikasarmi" was a Swedish military base. Later on, as Finland became an autonomous Grand Dutchy of Russia at the beginning of the 19th century, Helsinki was proclaimed capital in 1812. The town was then completely rebuilt and the area of the Naval Barracks was assigned by J. A. Ehrenström, for the construction of Russian military buildings.

German-born architect C. L. Engel arrived in Helsinki in March 1816 and was appointed architect in charge of the capital city's building committee. In Engel`s first design, the main building of the complex, the old sailor barrack, "Matruusi-rakennus" was in the area known as Kruunuhaka, where the city center was at the time.

After three months of planning, Engel was ready to submit his barracks layout for approval by the Tsar. At the outset, building conditions for the foundation work were difficult because of the winter weather as well as the proximity of the sea. Outer dimensions of the sailor barracks were to be 93 m x 13,4 m x 16 m in height, with 3 floors above basement level (photograph 1).

Photograph 1. Ministry of Foreign Affairs of Finland, old sailor barrack, north elevation (sea side). Basement and three stories.

In 1826 the Tsar ordered the construction of two adjacent wings, one as a kitchen wing and the other as an officer's and staff wing. The building complex was mostly completed in 1838. The two artillery warehouses from the time of the Swedish rule remained bordering the court on the east and west sides.

When Finland gained it's independence in 1917, the area was taken over by the Finnish Navy for use as a military harbour.

In 1972 the state council decide to place the Ministry of Foreign Affairs in the Naval Barracks, using all the existing structures and eventually demanding the creation of additional basement space.

2 STRENGTHENING AND UNDERPINNING WORK

Massive brick walls of the building rest on massive stone works and on stone foundations lying on moraine and on rock.

The walls of the old sailor barrack were shored during reconstruction, underpinning operations, rock blasting and digging process of the basement. Strengthening and underpinning work at site started in the fall of 1985 in the western part of the building, and ended in the fall of 1988 in its eastern part.

The ground engineering duties of the writers of this article covered geotechnical and structural designs of temporary and permanent structures. These designs were implemented for foundation work as well as for concrete structures from the basement to the ground floor level. These consisted of drilled steel piles, prestressed rock- and soil anchors, bolting stone walls, concrete arches etc. Tasks consisted risk analyses of blasting and vertical loads of working equipment against shored structures.

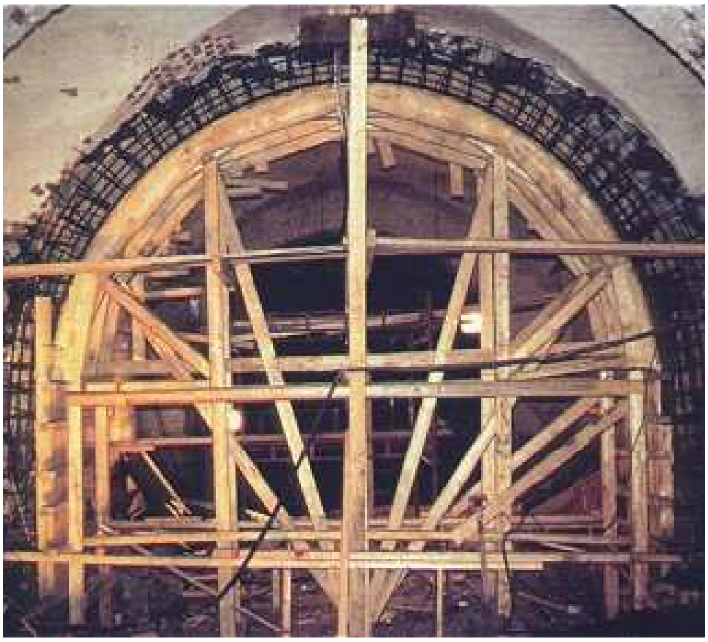
Digged moraine, blasted rock and loosed rock was mucked out level by level with heights ranging from 1 to 1.5 m. Throughout the blasting process it had to be verified that the just poured concrete foundations lying on rock and moraine had a minimal strength of 5.0 MN/m² (50 kp/cm²). Of course blasting could be done before setting time of the concrete and in certain circumstances before its limit penetration resistance. Vertical particle velocity was monitored in the eastern and western stair columns. The allowable velocity was 15 mm/s and the horizontal accident load from the work machines was estimated at 5 kN.

The engineer's duty also included design of the monitoring system as well as the design of the shoring. All the work was done under the supervision of the engineer. The level of earth on the seaside (the north side) was about approximately +1.00 and +7.5 on the south side. Before the underpinning work the level of the western basement of the building was +3.6 and the ground floor level +8.45. Furthermore in the eastern part of the sailor barrack, there was no basement floor because of rock level.

During construction stages the weight of substructure decreased temporarily because of demolishing old ceilings.

From the structural point of view, the building had three load bearing walls and two sectors:

- the northern wall on the sea side, the middle "kernwall" and the southern wall on the earth side
- because of the presence of surface rock, the three story building only had a basement on its western part
- both sectors, east and west, were divided by a perpendicular heavy stone wall
- during the underpinning work the perpendicular wall had to be demolished.



Photograph 2. Perpendicular wall. Temporary supports. Drilled steel piles. Reinforcement of concrete arch.

The substructure of the perpendicular wall was temporarily supported. Loads of the first floor were taken temporarily, partly by steel tension ties up to the old steal beams of the second floor, and partly on drilled steel piles (photograph 2). The permanent support of the substructure designed as a concrete arch, similar to the existing ones nearby, also acts to retain the earth pressures at rest.

3 MIDDLE WALL

After digging and rock blasting around and under the old brick column was done, a new concrete one was poured under it.

Loads of the middle wall were taken First on temporary structures and then on concrete structures as follows (figure 1-2):

- steel piles were drilled and cement grouted in the bedrock on both sides on the wall, because of the presence of stratified rock and because of blasting. The piles were designed separately as point bearing and as in-rock grouted piles.
- steel beams were installed through the brick wall
- wall loads were taken by jacking steel beams on piles. The jacking operation was controlled by levelling in order to find the right jacking forces. During the digging work drilled steel piles were braced by welding rolled steel angles between them, making trusses
- rock blasting with explosives was done around the trusses. The minimum distance from piles to smooth blasted face was 0.5 m
- in close distance to the steel piles and under brick columns / brick wall, only old hand methods of loosening rock by using close spaced holes, wedges and hammer were normally accepted. In some cases the loosening of rock could be done by hydraulic wedge machine (Darda) (photograph 3).
- form work and reinforcement were done inside the temporary steel structures and new columns were poured (photograph 4)

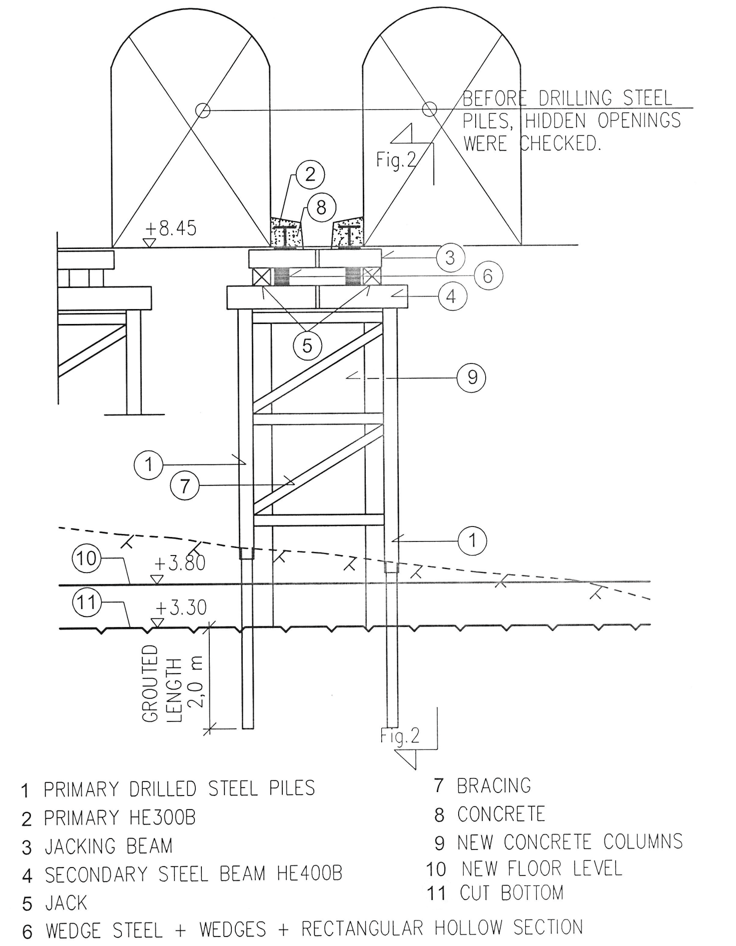


Figure 1. Middle wall. Drilled steel piles. Steel beams and jacking system. Bracing.

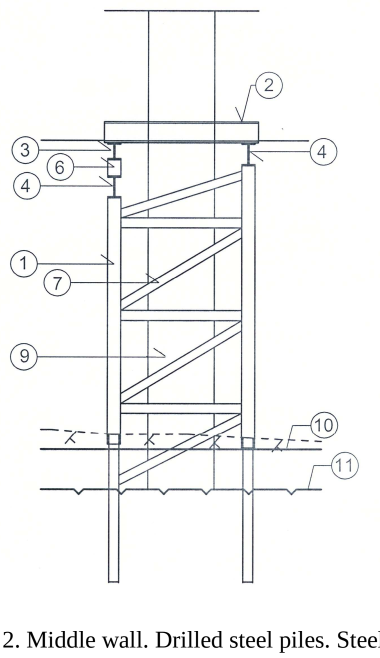


Figure 2. Middle wall. Drilled steel piles. Steel beams and jacking system. Bracing.

Photograph 3. Middle wall. Drilled steel piles. Smooth blasted face. Close spaced holes ready for old hand method loosening rock with hammer and wedges.

In the middle third of the middle wall, to establish a new floor level new foundations on moraine had to be realized. As mentioned previously, the loads were taken temporarily on steel piles. In this case the sides of the brick columns were prestressed by tension bars to prevent structural collapse during underpinning.

Steel piles were drilled by Odex-equipment, casing tube was 139.7 x 5 and the core was ϕ 80. Empty space between tube and core was grouted using cement mix w/c = 0.45 and additives.

Photograph 4. On the right: middle wall. Center: reinforced concrete column and temporary steel supports, braced steel pile truss. Left: injection work (northern wall).

4 SOUTHERN, EXTERNAL WALL IN THE WEST PART OF THE BUILDING

Nearby the southern wall a pipe channel was constructed to the level + 2.5 m. The old wall was not strong enough to retain the earth pressure at rest. To solve this retain problem some of the earth adjacent to the wall was substituted with Leca-aggregate, hence the pressure was minimized. The wall was also supported by using prestressed permanent rock and earth anchors (figure 3).

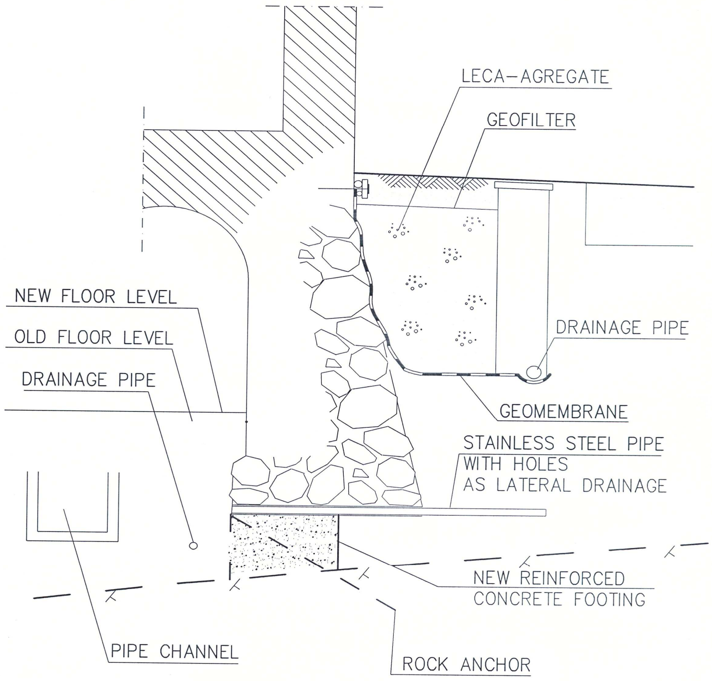


Figure 3. Southern wall. Soil pressure at rest minimized by using Lega-aggregate. Lateral drainage through wall. New footings and rock-anchors.

Footings of the southern external wall were underpinned as follows:

- the old stone foundation, lying on moraine, was grouted slightly before digging under the rock stone foundation. Underpinning pits were dug down to the rock. Also vertical and inclined dowels (ribbed steel bars) were installed before casting concrete in the pits. In some places, where the old stone foundation had to be cut in order to get more room inside, the foundation was first covered with shot crete and then grouted. Finally rock blasting was done, and explosives could be used as near as 0.5 m from the wall.

5 EASTERN AND WESTERN STAIR COLUMNS

The loads of the brick made stair columns were temporary supported by drilled steel piles as in the case of the middle wall. The irregular brick column was covered in a mantel of concrete. In order to get enough friction force between the concrete and the brick column the mantel was stressed against the brick column by tension bars. The mantel was divided in four sections by Styrofoam joints to be sure that pretension on the concrete plate is against brick column (figure 4, photograph 5).

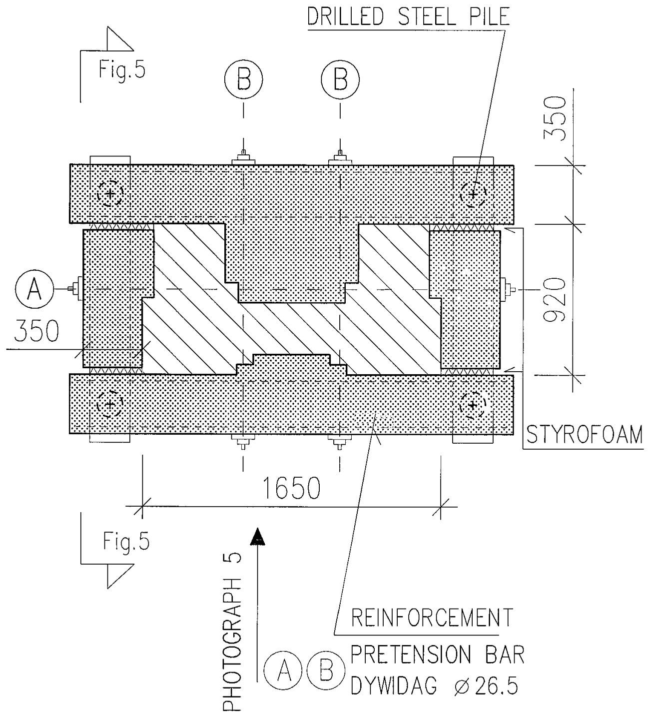


Figure 4. Eastern stair column. Structural stages. Pretensioned concrete mantel and drilled steel piles.

A concrete column was poured according to the measures of the brick column. To avoid blasting damages the whole column load was taken by vertical steel dowels between concrete and rock (figure 5, photograph 6).

The blasting and loosening of rock was made as mentioned previously for the middle wall.

Photograph 5. Eastern stair column. Structural stages. Old brick column. Pretensioned concrete plates. Temporary steel supports.

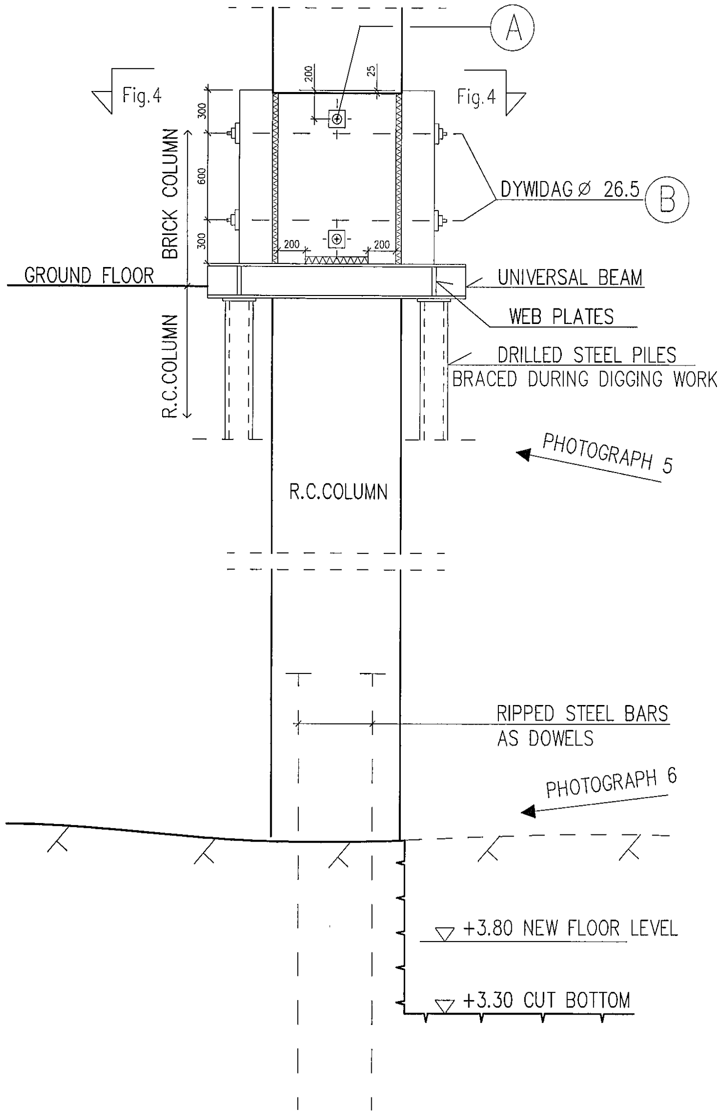


Figure 5. Eastern stair column. Structural stages. Pretensioned concrete mantel and drilled steel piles. Reinforcement concrete column. Levels of rock and blasted rock.

6 DISPLACEMENTS

Throughout the work the horizontal displacements of the middle wall were small because the loads were taken temporarily by steel piles which were grouted in rock and the loads on the beams were jacked against deflection. Possible dangerous situations were avoided by monitoring at regular intervals during the work. A very slight inclination of the southern wall towards the sea was registered the displacements were locally 2 mm (at level +3.99) and 4 mm (level +8.5). The reason for the displacement was thought to be a strike from the “Bobcat” or the result of blasting or both. As a precautionary measure more bracing was done.

Photograph 6. Eastern stair column. Structural stages. Loosened, fissured rock. Dowels and hammer visible.

7 REMARKS

Many other underpinning and strengthening works of lesser importance were also done throughout the building, although the above mentioned were by far the most important and challenging ones for this project. Also of consideration was the fact that during the whole period of digging and blasting, construction work was being done on the upper levels of the building.

For the reason that the building is of national heritage, designed by architect C. L. Engel, enough time was allocated to implement good design solutions.

The contractor who was responsible for this demanding project was one of a few Finnish companies with good experience and workmanship in the strengthening of foundations.

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